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ON THE REACTIVITY OF SOLIDS

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OFFICE OF NAVAL RESEARCH

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ENGLAND**

EIGHTH INTERNATIONAL SYMPOSIUM ON THE
REACTIVITY OF SOLIDS

P. J. HERLEY*

23 September 1976

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EIGHTH INTERNATIONAL SYMPOSIUM ON THE
REACTIVITY OF SOLIDS

by

P. J. HERLEY

The Eighth International Symposium on the Reactivity of Solids (ISRS) was held 14-19 June 1976 in Gothenburg, Sweden, the same location as the First ISRS 32 years ago. The host institution for the conference, Chalmers University of Technology, also contains the "Silikatforskning Institut," for so many years the home of the late Professor J. A. Hedvall. Both the chairman of the international conference committee, Professor P. Hagenmuller (University of Bordeaux), and the president of the organizing committee, Professor A. Magneli (University of Stockholm), in their opening addresses stressed the pioneering role of Hedvall in the field of Solid State Chemistry. Copies of his manuscripts, books and memorabilia were on exhibition during the conference.

Over 220 attendees were present from 29 countries. The main contingents were from France, West Germany and Sweden. One felt that the conference costs and the current economic situation may have contributed to the lack of U.S. support (12 attendees) and the relatively small number from the U.K. Nevertheless, the efforts of the organizing committee to achieve a good international mix were highly successful. However, as is the case so often these days at international conferences, all of the USSR scientists who had submitted abstracts did not attend and thus their papers were cancelled. In view of a few late entries and the somewhat demanding pace of the conference, their absence was not altogether a misfortune; in some poster sessions additional space became available for impromptu poster displays! In eight sessions over 108 papers were either orally presented or displayed as posters. This was the largest number of papers ever presented at any ISRS conference. As the poster sessions ran concurrent with the lectures, posters were available for viewing and discussion during the whole morning or afternoon.

The Symposium was opened officially by Professor Lundgren (University of Gothenburg) followed by Hagenmuller in a crowded (just built) lecture theatre. They, in turn, were followed by Magneli who introduced the first session on reactions at surfaces and interfaces especially at elevated temperatures, e.g., hot corrosion, or reactions between surface layers and bulk material. Particular mention was made during his talk of the work of the late David Wadswley on extended defects in solids. The orally presented papers in this session dealt mainly with oxide or oxide-type systems: e.g., reaction kinetics in the Ca-Mn-O Systems by J. Longcn *et al* (Exxon Research & Engineering Company, New Jersey); and the influence of intrinsic defects on the solid-state reaction mechanisms between CdTe and HgSe by V. Lenti *et al* (University of Munster, FRG). The role of surface reactivity was emphasized by L. Burlamacchi *et al* (Universita di

Firenzi, Italy) in olefin oxidation of cadmium molybdate doped with transition metal ions; by H. J. Grabke *et al* (Max-Planck-Institut für Eisenforschung GmbH, Dusseldorf) on the chemisorption of sulfur on iron; and by F. S. Stone *et al* (University of Bath, U.K.) on the reactivity of finely divided CoO-MgO solid solutions. A paper on the results of x-ray photoelectron spectroscopy to determine the valence states of some tungsten oxides by M. Schiavello *et al* (Centro di Studio sulla Struttura et Attività Catalitica di Sistemi di Ossidi del CNR, Rome, Italy) concluded the first part of this session. The remaining papers dealt with crystallite growth (e.g., oxide crystallites during the oxidation of iron in carbon dioxide in the scanning electron microscope) by P. Surman *et al* (Central Electricity Research Laboratories, Leatherhead, England) and a topotactic study of the interaction of metal oxides and sulfides with lithium by M. Stanley Whittingham *et al* (Exxon Research & Engineering Co., New Jersey). Their results indicated that non-stoichiometric ternary compounds result, but these usually have crystal structures close to the starting material. Also an interesting paper was presented by Udo Pitteman *et al* (Technische Hochschule Darmstadt, FRG) on measuring surface temperatures using temperature-dependent chemical equilibria as a probe: $(Ag + CuI \rightleftharpoons AgI + Cu)$ for the special case of the evaporated species being a salt. The final three papers concerned themselves with classical oxygen diffusion measurements using solid/gas isotope exchange in strontium titanate single crystals, R. Haul *et al* (Tech. University, Hannover, FRG); the oxidation of zirconium nitride by J. G. Desmanson *et al* (Université de Limoges, France); and of nickel telluride between $NiTe_{0.8}$ and $NiTe_{2.0}$, D. Kolar (University of Ljubljana, Yugoslavia).

The first poster session of 21 papers could be arbitrarily divided into those dealing with either kinetic aspects of surface reactions or physical phenomena relevant to interface reactions. Among the latter category were poster presentations by A. Passerone *et al* (Centro Studi di Chimica e Chimica Fisica Applicata CNR, Genoa, Italy) on equilibrium wetting in titanium-molten glass systems and an electron microscopic determination of crystal rearrangements in the dehydration of cadmium hydroxide and barium oxalate by J. C. Niepce *et al* (Faculté des Sciences Mirande, Dijon, France). The presentation dealing with kinetic determinations covered a wide range of compounds: oxygen on finely divided magnetites by B. Gillot *et al* (Faculté des Sciences Mirand, Dijon, France); peroxide and superoxide catalyst's influence on the equilibria in molten $(Na,K)NO_3$ equivalent mixtures by E. Desimoni *et al* (Università di Bari, Italy); the oxidation of Cr_2O_3 in the presence of selected $MM'O_3$ oxides, T. Nishino *et al* (Musashi Institute of Technology, Setagaya, Tokyo, Japan); and the oxidation of cobalt from 950-1,300°C by S. Mrowec *et al* (Academy of Mining & Metallurgy, Krakow, Poland). Self-diffusion coefficients for cobalt in cobaltous oxide ($Co_{1-y}O$) were obtained and the activation energies and pressure dependence of the process in the oxygen pressure range 6.58×10^{-4} to 0.658 atm were determined.

Proceeding on with further poster papers: G. Perugini (Montedison, Novara, Italy) studied the kinetics of titanium oxidation with air

at 850°C to form surface oxides for use as protective coatings. When nickel is present on a second layer, a highly ceramized effect is obtained because of the formation of mixed oxides. M. Yonemura *et al* (National Chemical Laboratory for Industry, Mita, Tokyo, Japan) had two poster presentations, one on the kinetics of solid solution formation (NaCl-KCl and CaO-SrO systems) and the other on the phase transformation kinetics of GeO₂. Several spinel solid solutions were examined by F. Pepe *et al* (Centro di Studio sulla Struttura et Attività Catalitica di Sistemi di Osside del CNR, Rome, Italy) in which the cation distribution was observed with an increase in temperature.

Thermal balance techniques and thermal decomposition kinetic phenomenology were utilized in studies of a low temperature spinel formation by Z. G. Szabo *et al* (L. Eotvos University, Budapest) and in studies of calcium carbonate powder decomposition kinetic by Gy. Pokol *et al* (Technical University, Budapest, Hungary). M. Brown *et al* (Rhodes University, Grahamstown, South Africa) used the pressure evolution method and electron microscopy to study the nucleation process in the thermal decomposition of nickel formate. The formation of nuclei within the reactant mass was inhomogeneous, attributable to changes in the prevailing water vapor pressure during decomposition.

The second formal session on the influence of structural defects on the reactivity of solids appeared to be one area in which a large amount of progress has been made since the last Symposium. The plenary speaker was Professor H. Schmalzried (Technical University, Hannover, FRG), who emphasized the role of solid state defects in chemical reactivity. His theme was evident throughout the subsequent presentations: Defect studies on strontium ferrate by B. Tofield (AERE, Harwell, England); on ferroelectric compounds by J. S. Anderson's group now at the University of Wales, Aberystwyth, (formerly at Oxford) on finely ground nickel powder by J. Carriou *et al* (ETSII, University of Seville, Spain), on two studies of lanthanum-doped barium titanate by D. Hennings and R. Werneke (Philips GmbH, Aachen, Germany). Structural defect-type studies were also presented on FeF₃-WO₃ systems by J. M. Dance *et al*, in Hagemuller's group at Bordeaux and on some perovskite materials by K. J. de Vries *et al* (Twente University of Technology, Enschede, The Netherlands) and on thallous tungstates by R. Rastogi *et al* (Gorakhpur University, Gorakhpur, India).

F. Felix *et al* (Hahn-Meitner-Institut für Kernforschung, Berlin) presented the only paper on irradiation damage in solids; the formation of large defects in neutron-irradiated alkali halide crystals. Voids were formed with neutron doses from 1.5×10^{16} to 4.5×10^{18} n cm⁻², with an average volume/void of 10^{-12} to 10^{-10} cm³. Two dimensional arrangement of voids were found to occur parallel to (110)-planes. Correlations between the crystal structure and decomposition kinetics of some inorganic azides were the subject of a very thorough study by H. T. Spath (Technische Universität, Graz, Austria). Professor J. Haber's group (Polish Academy of Sciences, Krakow, Poland) presented a study of the reduction kinetics of cobalt molybdate in hydrogen which occurs by a shrinking sphere model with an activation energy

of 28.2 kcal mole⁻¹. The last orally presented paper in this session was by T. Baird and his group (University of Glasgow, Scotland) on the reactivity of some divalent metal hydroxides with silica gel. Specific silicates of calcium, magnesium and zinc were formed, and possible reaction mechanisms were discussed.

The attendant poster session contained many interesting papers over a wide range of defect structures; a sampling of these is given below. The quality of presentation varied markedly in this session, and one felt that some sort of guidelines should have been suggested for the posters. Dislocations were characterized by etch pit studies in barium perchlorate and their role on the subsequent dehydration process were discussed by G. T. Guarini *et al* (University of Florence, Italy). The miscibility gap in $Mn_xCr_{3-x}O_4$ spinels was subjected to a detailed investigation with careful determinations of the three phase regions in which the spinel phases are present, by E. Pollert *et al* (Physical Institute CSAV, Praha, Czechoslovakia).

Large (5 x 5 x 5 mm) single crystals of ammonium perchlorate enabled P. Herley *et al* (State University of New York, Stony Brook) to limit the low temperature decomposition to a small surface layer only with retentions as high as 96%. Their results were interpreted in terms of the defect substructure of the crystals. Structural defects were also important in the trapping of hydrogen in α -iron as reported by E. M. Riecke (Max-Planck Institut für Eisenforschung GmbH, Düsseldorf, FRG). The traps were assumed to be dislocations and dislocation pile-ups with dislocation densities of 5×10^{11} cm/cm³. D. Dollimore and his group (Chemistry Dept., University of Salford, England) showed that certain surface textures of dehydrated stannic acids absorb water on particles which can be identified as small crystallites of cassiterite. Stannic oxide-manganese oxide solubilities were one system examined as part of redox processes of manganese ions dispersed in oxides by M. Valigi (Istituto Chimico, Università di Roma, Italy).

Electron microscopic results of lattice images of Mo oxide phases produced by the reduction of MoO₃ by hydrogen were presented by G. Liljestrand (Arrhenius Laboratory, Stockholm, Sweden). His techniques verified earlier domain structures, and in addition several rather different compositions ($Mo_{10}O_{46}$ - $Mo_{19}O_{55}$) could be identified within the same crystal depending on the oxygen pressure during growth. Using diverse techniques for the reduction of simple and combined oxides of iron, I. Gaballah *et al* (Université de Nancy, France) showed that polymorphic, magnetic transformations, and probably point-defects and dislocations influence the activation energy and sometimes the rate of the reaction. M. Nakahira *et al* (Okayama College of Science, Okayama, Japan) presented data on the non-quenchability of some transition-metal chalcogenides, e.g., the VS-VS₂(V_{0.5}S) system. Intra- and inter-layering disordering was observed with increasing temperature up to 800°C above which intra-layering was complete while the inter-layering continued to increase up to 50% at 1,000°C. J. Haber *et al* (Polish Academy of Sciences, Krakow, Poland) using electron microprobe analysis examined the mechanism and kinetics of the solid state reaction between

CuCr_2O_4 - $\text{Cu}_2\text{Cr}_2\text{O}_4$ - CuO in the temperature range 820-850°C. During the first stage the rate determining step is the removal of chromium oxide from the CuCr_2O_4 grains; in the second stage the rate is diffusion controlled. J. Guenot *et al* (Université Paris VII, France) discussed topotactic relationships in solid-gas reactions using cobalt compounds as examples. While topotactic relationships are always present at the beginning of the reaction, they are maintained to a greater or lesser degree during the course of the reaction depending on the degree of strain "relief" that produces misoriented crystallites. S. T. Buljan *et al* (Penn State University, University Park, PA) evaluated the microstrain and the mechanism of the reversible monoclinic tetragonal phase transformation in zirconia. The extent of the coherent interface between the two phases could explain the behavior of the microstrain. J. Krigesmann *et al* (Technische Universität Clausthal, FRG) measured the mechanical damping of doped polycrystalline MgO . A symmetric Debye type peak was found with the specimen containing Li^+ with an activation enthalpy of (2.94 ± 0.53) eV. P. Y. Eveno *et al* (Laboratoire d'Etudes et de Synthèse des Microstructures CNRS, Meudon-Bellevue, France) concluded the session with a poster on the mechanism of ferrite formation in Fe_2O_3 - Mn_3O_4 and Fe_2O_3 - NiO couples. They concluded that one of the basic parameters governing the ferrite formation was the relative value of the cation diffusion coefficients.

The third session, the smallest in the Symposium, was introduced by Professor H. Morawitz (Polytechnic Institute of New York, Brooklyn). The theme was solid state reaction in organic materials, including polymers. Morawitz has long been associated with polymeric reactions, and his talk was enthusiastically received. Of the five organic papers presented at the symposium, two were by D. J. Morantz *et al* (London College of Printing, England) on laser-induced reactions in doped polymethylmethacrylate and the effects of x-ray and uv irradiation, and room temperature phenomena in doped solid polymer matrices. Other papers included in this session were: the thermal isomerization of cisazobenzene in the solid state by H. K. Cammenga *et al* (Universität Braunschweig, FRG); energy transfer in the solid state photopolymerization of diacetylenes by G. Wagner *et al* (Universität Freiburg, Freiburg im Breisgau, FRG) and bromination of organic solids by E. Hadjoudis (Chemistry Department, Nuclear Center "Demokritos," Athens, Greece).

The following session's primary speaker was Professor W. Vogel (Friedrich-Schiller Universität, Jena, GDR) who introduced the theme: reactions in vitreous solids. Two papers were orally presented in this session; thermal decomposition of rhodium oxide gels by E. Moran *et al* (Departamento de Química Inorgánica, Cantoblanco, Madrid, Spain) and polymerization effects during the crystallization of silicate glasses by J. Gotz *et al* (Joint Laboratory for Silicate Research of the Czechoslovak Academy of Sciences and the Chemical University, Prague, Czechoslovakia). The three poster papers were; first, by H. Verwey *et al* (Philips Research Laboratories, Eindhoven, The Netherlands) who used laser Raman spectroscopy to investigate the process of formation of a $30\text{K}_2\text{O} \cdot 0.70\text{SiO}_2$ (molar composition) glass. Glassy and crystalline intermediate products were identified by the well-known "finger point" method; second, by

E. Phillippot *et al* (Université des Sciences et Techniques de Languedoc, Montpellier-Cedex, France) who examined the relations between color, thermoluminescent curves and the structure of some Si, Ge and Sn ternary chalcogenides; and, finally, by L. Hermansson *et al* (Swedish Institute of Silicate Research, Gothenburg) who used x-ray diffraction and DTA techniques to examine the phase transitions of solid solutions of leucite by crystallization of glasses in the $K_2O-CaO-Al_2O_3-SiO_2$ system. They reported that while the unit cell dimensions change continuously with temperature, a discontinuous change in the unit cell dimension of leucite was observed at 625°C. The low temperature form is cubic and the high temperature form tetragonal. The linear thermal expansion for the high temperature form was reported as $(11.7-12.8) \times 10^{-6}(C^{-1})$ (from 25-600°C).

The penultimate session, on new developments in experimental techniques for the study of reactivity of bulk solids and solid surfaces, featured Professor E. G. Derouane (Facultés Universitaires Notre-Dame de la Paix, Namur, Belgium) as the plenary lecturer. He discussed in detail the thermal decomposition of bulk solids and the new methods available for examining kinetics and reactive species in bulk solids. Oxides and oxidation processes also figured prominently in this session. W. Gunsser *et al* (Institut für Physikalische Chemie der Universität Hamburg, FRG) used EPR to examine solid state mixtures of thermally decomposed $Y(OH_3)$ and $Ga(OH_3)$. C. Coddet *et al* (Département de Génie Mécanique--Université de Technologie de Compeigne, France) using photo-emission electron microscopy examined the behavior of argon-ion sputtered clean surfaces of pure titanium and Ta_6V_9 alloys at 600-900°C when oxygen gas was introduced. The oxidation process has general features corresponding to a nucleation and growth mechanism. The shapes of the nuclei, however, were not well-defined. Oxygen diffusion studies in NiO and ZnO using O^{18} tracer techniques were carried out by D. Hallwig *et al* (Universität Erlangen-Nürnberg, Erlangen, FRG). The activation energy (250 kJ mol^{-1}) and diffusion coefficients for NiO and for ZnO below 900°C agree well with findings of other workers. Above 900°C there is a difference in values as ZnO evaporates in an H_2O -containing atmosphere. Oxygen diffusion in quartz was studied using activation analysis of the reaction $O^{18}(p,n)F^{18}$ by R. Schachtner *et al* (Universität Erlangen-Nürnberg, Erlangen, FRG). Diffusion coefficients were obtained up to 1,000°C. No relationship between the orientation of the sample-surface relative to the c-axis and the diffusion coefficient could be observed.

Other systems involving oxides that were presented included: the sulfurization of nickel oxide single crystals by hydrogen sulfide, presented by A. Steinbrunn *et al* (Laboratoire de Recherches sur la Réactivité des Solides Associé au CNRS, Dijon, France). LEED, RHEED, AES were used to observe a two-dimensional adsorption layer of sulfur on the oxide. Nickel sulfide growth then develops following the same mechanism as that for growth in the case of pure metals. The sulfation (SO_4^{2-}) mechanism of CoO and NiO was studied using gold-marker diffusion-type experiments by L.E.K. Holappa *et al* (Department of Metallurgy, Helsinki University of Technology, Otaniemi, Finland). The kinetics and gold-marker experiments showed that both nickel and cobalt sulfates grow outwards on the initial oxide surfaces.

Electron microscopy (EM) also featured prominently in the new developments: high resolution EM studies of fluorite-related cerium oxides were reported by O. Toft Sorensen (Danish Atomic Energy Commission, Risø, Denmark). Much more order in the non-stoichiometric cerium oxides were observed than previously envisaged. G. Schiffmacher *et al* (Laboratoire des Terres Rares du CNRS, Bellevue, France) also used high resolution EM to study the stepwise decomposition of layered hexagonal hydroxycarbonates to oxides.

P. Butcher *et al* (V. G. Scientific, Ltd., East Grinstead, England) presented some data on adsorbate layers (He I) on Ni (111) surfaces using a newly developed ADES 400 angular-dispersion photoemission electron spectrometer. The Ni-Co system was also examined, and the data were found to be consistent with a recent SCF-X α cluster calculation for Co on Ni (100) surfaces.

The theoretical studies in this session were directed toward simulation of crystal events, e.g., M. B. Ives *et al* (McMaster University, Hamilton, Canada) presented a paper on the computer simulation of crystal dissolution modeled on processes occurring during the free evaporation from a perfect (100) copper surface. The simulation demonstrated that several surface events produced by the use of Morse pair-wise potential functions do not contribute to a new change in surface morphology. J. Demarquay *et al* (Institute de Recherche sur la Catalyse CNRS, Villeurbanne, France) presented a theoretical study of simulation dehydration of crystal silica planes and a determination of the silica gel hydroxyl distribution by NMR. Calculated nuclear dipole interactions due to OH groups on different silica planes when compared with experimental NMR results revealed the specific dehydration types of OH groups at each temperature and also the remaining OH⁻ distribution on the silica planes.

P. A. Parrish *et al* (USARO, Research Triangle Park, North Carolina) studied the influence of interstitial hydrogen (introduced by electrolytic charging) upon microstructural properties of silicon modified 4340 steels, some containing austenite. The hydrogen analysis was conducted by utilizing a unique hydrogen detection system (a selective permeation of hydrogen through a semipermeable metallic membrane-sensitivity 10 parts/billion). Their results indicated that the austenite provided an effective trap for immobilizing hydrogen and enhanced the resistance of the steel to hydrogen embrittlement cracking.

The final two papers reflected directly the emphasis of the plenary speakers, the first by A. Taskinen *et al* (Helsinki University of Technology, Espoo, Finland) was a "classical" kinetic study of the thermal decomposition of α -cobalt oxalate. For this phase the Avrami-Erofeev equation was fitted to isothermal fractional decomposition vs time data between 619-700 K. A well-developed α/β phase mixture exhibited different kinetics over the initial induction and acceleratory periods. However, the resulting activation energies for both samples were almost the same depending on the temperature range. The second paper by E. G. Derouane *et al* (Chemistry Department, University of Namur, Belgium)

used thermogravimetry, mass spectrometry, EPR, ir-spectroscopy and x-ray diffraction to investigate the role of dispersed Cr(V) and Cr(III) ions at the surface of various oxides. Alkaline earth chromates, oxalates and chromate/oxalate mixtures of barium, strontium and magnesium were thermally decomposed to produce the required surfaces. Several consistent decomposition mechanisms with identifiable intermediate species were proposed from the data in the temperature range from 20 to 800°C.

The last session's theme was solid-state reactions in technology introduced by Professor R. L. Coble (Massachusetts Institute of Technology). His lecture was one of the highlights of the conference, and he summarized very succinctly what relevant areas should be studied in solid reactions, e.g., sintered materials, materials for uses at high temperature, coatings, complex alloy systems. He also emphasized how complex the interpretation of even the simplest data could become. Coble proposed that more theoretical approaches be examined to explain existing data, e.g., simulation studies, with the hope that a more formalized comprehensive picture might emerge on solid reactivity.

The materials technology section comprised a wide range of topics. M. Kermarec *et al* (Cinétique des Reactions Superficielles, 4 Place Jussieu, Paris) studied the kinetics of the reduction of Ni^{2+} ions in an X-type zeolite. R. W. Vest (Purdue University, West Lafayette, Indiana) studied the development of conductive chains in RuO_2 -glass thick-film resistors involving glass sintering; glass spreading, micro-rearrangements, glass densification and conductive sintering. The kinetics of these processes were influenced by surface tension, viscosity, particle size of the glass and of RuO_2 , solubility of RuO_2 in the glass and the contact angle of the glass on RuO_2 . Y. Yamaguchi *et al* (Department of Engineering, Keio University, Yokohama, Japan) studied the effects of starting materials and mixing conditions in the solid state reaction between barium carbonate and titanium dioxide. The kinetics and reaction mechanism involving intermediate phases were discussed with special emphasis on the effect of mixing performance. J. G. Lee *et al* (University of Utah, Salt Lake City) examined the production of silicon carbide, silicon nitride or silicon mononitride by the carbothermal reduction of silica. The mechanism of silica reduction involved a chain reaction, gas-solid scheme. Both silica and carbon surfaces were involved. An explanation for the role of iron as a catalyst was given. B. Heed *et al* (Chalmers University of Technology, Gothenburg, Sweden) measured the conductivities of sulfate-based solid electrolytes at room temperature. A power density of 400 W/kg was obtained at 745°C for the cell $Mg/Li_{1.76}Mg_{0.12}SO_4/MnO_2$. B. Schollhorn (Münster University, Münster, Germany) observed that, at room temperature, electronically conducting two-dimensional layer units of dichalcogenides were retained during redox conversions as topotactic matrix elements. High ionic mobilities were found for guest cations in these systems.

Other papers presented in this session included: preparation and properties of $FeOCl$ -pyridine derivative complexes and their reactivities

with methyl alcohol by S. Kikkawa *et al* (The Institute of Scientific and Industrial Research, Osaka University, Japan); steps in the low temperature dehydroxylation of clay by M. Gabor *et al* (L. Eotvos University, Budapest); co-precipitation of metal ions during ferrous hydroxide gel formation by S. Okamoto *et al* (The Institute of Physical and Chemical Research, Wako-shi, Saitama, Japan); and mass transport by self-diffusion and evaporation-condensation in high temperature kinetic processes in UO_2 - PuO_2 nuclear fuel by Hg. Matzke (European Institute for Transuranium Elements, EURATOM, Karlsruhe, FRG). A Rabinau (Max Planck Institut, Stuttgart, FRG) discussed the formation and some of the unusual properties of the subhalides of tellurium. Phase diagrams, ionic conductivity data and the optical absorption spectra were presented.

The final poster session contained investigations of reaction kinetics, e.g., between various particle sizes of magnesium oxide and ferric oxide by J. Beretka *et al* (Division of Building Research, CSIRO, Victoria, Australia), dehydration and reduction kinetics of goethite into magnetite by M. L. Garcia-Gonzales *et al* (Université Catholique de Louvain, Louvain-la-Neuve, Belgium), and phase equilibria, V. S. Stubican *et al* (Penn State University, PA). Stubican and his co-workers had redetermined the solubility of WC in ZrC and TiC. They also reported that the rate of precipitation of WC from (W, Zr)C and (W, Ti)C solid solutions followed a square root time-dependence. A. G. Revesz, *et al* (COMSAT Laboratories, Clarksburg, Maryland) used secondary ion mass spectrometry and gravimetric analyses to study substrate-film interactions in Si-Ta(Ta_2O_5) structures. The results were compared with those obtained from optical measurements. R. Warren *et al* (Chalmers University, Gothenburg, Sweden) concluded the session with their poster on the structural degradation of carbon fibers in nickel at elevated temperatures (800-1,300°C). For all fiber types, nickel catalyzes the graphitization of the fiber structure. There was a drastic reduction in fiber strength as the nickel penetrates to the center of the fiber. Possible graphitization mechanisms were discussed.

No sooner was the symposium officially closed by Professor Lundgren than the attendees were promptly invited by Professor J. Haber (Polish Academy of Sciences) to participate in the next (IXth) ISRS to be held in Krakow, Poland, in 1980. The proceedings of this Symposium (including edited comments on several of the presentations and posters) is scheduled to appear as a somewhat massive tome as soon as November 1976! No one was prepared to guess at the price, but one will surely get value for one's money.

CONCLUSIONS AND FUTURE PERSPECTIVE

The reactivity of solids, the chemistry of the solid state, is alive and well. Indeed, it is thriving, diversifying and has grown enormously in the past few years. The organizing committee for the Conference under the able direction of Professor Magneli are to be congratulated on an excellent and worthwhile effort both in the standard and the "heterogeneity" of the papers presented and in the distribution of the international attendees.

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Looking to 1980, I would question why so few papers were offered in the organic/polymer section. Surely this small number does not reflect the current advances in solid-state organic chemistry. Also, I would have liked to have had more time for follow-up discussions within each session: perhaps like the Faraday Symposia, where the papers are assumed to have been already read and extensive discussion periods are allowed, say after presentation of three or four papers. One final suggestion; since posters now seem to be a permanent part of symposia, I would like to have seen some minimum uniform requirements set for their presentation; I am sure the committee was aware of the wide variation in the quality of poster presentations.

In toto, the Symposium was a definite success and fruitful; no more could be asked of any scientific meeting.